In the Title

Kindly remove the heading "DESCRIPTION" before the title.

Kindly replace the title with the following:

~~GRAIN ORIENTED ELECTRICAL SHEET AND~~ METHOD FOR ~~MANUFACTURING THE SAME~~ PRODUCING GRAIN ORIENTED MAGNETIC STEEL SHEET AND GRAIN ORIENTED MAGNETIC STEEL SHEET

In the Specification

Kindly replace the first paragraph on page 1 with the following:

~~The present invention~~ This disclosure relates to a grain-oriented electrical steel sheet with excellent magnetic and bend properties, and to a method for manufacturing the grain-oriented electrical steel sheet consistently. In particular, ~~the present invention~~ the disclosure provides an advantageous effect when a steel sheet is, but not limited to, strip-shaped or a steel strip.

Kindly replace the third paragraph on page 1 with the following:

For example, methods in which MnS or MnSe (~~Patent Document 1~~ Japanese Examined Patent Application Publication No. 51-13469) and AlN are used as inhibitors have already been put to practical use. Furthermore, BN and nitrides of Ti, Zr, and V are also known as inhibitors.

Kindly replace the first paragraph on page 2 with the following:

In conventional methods as described in ~~Patent Document 1~~ Japanese Examined Patent Application Publication No. 51-13469, finishing-annealing typically includes secondary-recrystallization annealing and subsequent purification annealing for the purpose of film formation and purification.

Kindly replace the third paragraph on page 2 with the following:

On the other hand, the purification annealing is typically performed in hydrogen-based atmospheres, preferably in a hydrogen atmosphere to enhance the removal of impurities in the steel, such as an inhibitor. In particular, a nitrogen as a component of the atmosphere is not preferred, because a high nitrogen content results in insufficient removal of nitrogen in the steel, and therefore little improvement in the magnetic property of the steel sheet can be achieved. For example, ~~Patent~~

~~Document 2~~ Japanese Unexamined Patent Application Publication No. 11-158557 describes the adverse effect of a nitrogen atmosphere (about 0.1-0.4 atm) in the purification annealing.

Kindly replace the fourth paragraph on page 3 with the following:

In contrast to these methods, methods for manufacturing a grain-oriented electrical steel sheet without using inhibitors are disclosed in ~~Patent Documents 3, 4, and 5~~ Japanese Unexamined Patent Application Publication Nos. 64-55339, 2-57635 and 7-197126.

Kindly replace the fifth paragraph on page 3 with the following:

All the methods in ~~Patent Documents 3, 4, and 5~~ Japanese Unexamined Patent Application Publication Nos. 64-55339, 2-57635 and 7-197126 preferentially develop a {110} surface by using surface energy as a driving force. Thus, impurities in the steel sheet are reduced in advance and then finishing-annealing at high temperature is performed in a controlled atmosphere to prevent the generation of surface oxides to enhance secondary-recrystallization.

Kindly replace the paragraph bridging pages 3 and 4 with the following:

For example, ~~Patent Document 3~~ Japanese Unexamined Patent Application Publication No. 64-55339 describes a technique for preparing an integrated recrystallized structure with {110} <001> orientation, in which a silicon steel sheet prepared by melting highly purified raw materials, such as electrolytic iron, is rolled to a thickness of 0.2 mm or less, and is then heat-treated at 1180°C or more in vacuo or in an atmosphere of an inert gas, hydrogen, or a mixture of hydrogen and nitrogen.

Kindly replace the first full paragraph on page 4 with the following:

~~Patent Document 4~~ Japanese Unexamined Patent Application Publication No. 2-57635 describes a technique in which a commercial silicon steel strip is coated with an annealing separator to remove impurities, such as AlN and MnS, is purified at 1100-1200°C under a hydrogen

atmosphere for 3 hours or more, is cold-rolled to a thickness of 0.15 mm or less, and is then subjected to secondary-recrystallization annealing at 950-1100°C in an atmosphere of an inert gas such as Ar, hydrogen, or a mixture of hydrogen and an inert gas, and preferably under reduced pressure.

Kindly replace the second paragraph on page 4 with the following:

In ~~Patent Document 5~~ Japanese Unexamined Patent Application Publication No. 7-197126, silicon steel in which S, an impurity having a particularly large adverse effect, is reduced to 10 ppm, is subjected to short-time finishing-annealing at 1000-1300°C in a nonoxidative atmosphere with an oxygen partial pressure of 0.5 Pa or less, or in vacuo for 10 minutes or less.

Kindly replace the first paragraph on page 5 with the following:

The above-mentioned manufacturing processes that utilize surface energy do not require as high a temperature as the conventional methods used to heat the slab, but they have the following problems:

First, for effective use of the surface energy difference, the thickness of a steel sheet must be small to increase the contribution of the surface. For example, in the techniques disclosed in ~~Patent Documents 3 and 4~~ Japanese Unexamined Patent Application Publication Nos. 64-55339 and 2-57635, the thicknesses of the steel sheets are limited to not more than 0.2 mm and 0.15 mm, respectively.

Kindly replace the paragraph bridging pages 6 and 7 with the following:

Under these circumstances, in ~~Patent Documents 6 and 7~~ Japanese Unexamined Patent Application Publication Nos. 2000-129356 and 2000-119824, ~~the present inventors~~ we proposed techniques for developing a Goss-oriented crystal grain during secondary-recrystallization of

materials that do not contain an inhibitor by controlling the difference in the grain boundary mobility (details are shown below). Using these techniques, crystal grain can be brought into Goss orientation without using surface energy, thus overcoming the problems described above. For example, since these techniques are not limited by the surface condition of the steel sheet, an annealing separator can be applied to the steel sheet before finishing-annealing to form a film, such as a forsterite film, and thereby iron loss can be improved. For convenience, the grain-oriented electrical steel sheet proposed in ~~Patent Document 6~~ Japanese Unexamined Patent Application Publication No. 2000-129356 and the like is hereinafter referred to as inhibitor-free steel sheet.

Kindly replace the paragraph bridging pages 7 and 8 with the following:

In the technique proposed in ~~Patent Document 6~~ Japanese Unexamined Patent Application Publication No. 2000-129356 and so on, since the Al content is reduced to a predetermined level and the S and Se contents are also limited, conventional purification annealing is not necessarily required and the steel sheet is simply heated to a temperature at which a film, such as a forsterite film, forms after the secondary-recrystallization annealing. For example, ~~Patent Document 6~~ Japanese Unexamined Patent Application Publication No. 2000-129356 shows a finishing-annealing condition in which annealing is completed by heating the steel sheet to about 950-1050°C at a rate of about 15-20°C/h in a nitrogen atmosphere or nitrogen-containing atmosphere.

Kindly replace the first full paragraph on page 8 with the following:

However, purification annealing is not necessarily precluded in the technique, and purification annealing that allows for further reduction of impurities in the steel is rather effective in further improving the magnetic properties. For example, ~~Patent Document 7~~ Japanese Unexamined Patent Application Publication No. 2000-119824 discloses a technique in which the finishing-

annealing is performed by heating the steel sheet to 1180°C in a mixed atmosphere of 50% hydrogen and 50% nitrogen, and then by keeping the steel sheet at 1180°C for 5 hours in a hydrogen atmosphere. Even if purification annealing is performed, the absence of inhibitors results in a reduced operating load. For example, purification annealing at a lower temperature can achieve a sufficient effect.

Kindly replace the second paragraph on page 8 with the following:

Furthermore, in some techniques, secondary-recrystallization annealing and purification annealing are indistinguishable from each other. For example, ~~Patent Document 7~~ Japanese Unexamined Patent Application Publication No. 2000-119824 discloses a technique in which the finishing-annealing is performed by increasing the temperature to about 1100°C at a rate of about 20°C/h in a mixed atmosphere of 50% hydrogen and 50% nitrogen, or by increasing the temperature to 1200°C at a rate of 15°C/h in a hydrogen atmosphere.

Kindly replace the paragraph bridging pages 8 and 9 with the following:

~~Patent Document 8~~ Japanese Unexamined Patent Application Publication No. 2000-119823 describes a technique in which finishing-annealing is performed using steel that is free of inhibitors at about 1000-1150°C in an atmosphere of, for example, nitrogen, Ar, hydrogen, 50% hydrogen and 50% nitrogen, 50% nitrogen and 50% Ar.

~~[Patent Document 1]: Japanese Examined Patent Application Publication No. 51-13469~~

~~[Patent Document 2]: Japanese Unexamined Patent Application Publication No. 11-158557~~

~~[Patent Document 3]: Japanese Unexamined Patent Application Publication No. 64-55339~~

~~[Patent Document 4]: Japanese Unexamined Patent Application Publication No. 2-57635~~

~~[Patent Document 5]: Japanese Unexamined Patent Application Publication No. 7-197126~~

~~[Patent Document 6]: Japanese Unexamined Patent Application Publication No. 2000-129356~~

~~[Patent Document 7]: Japanese Unexamined Patent Application Publication No. 2000-119824~~

~~[Patent Document 8]: Japanese Unexamined Patent Application Publication No. 2000-119823~~

Kindly replace the paragraph bridging pages 9 and 10 with the following:

~~Disclosure of Invention~~

~~[Problems to be solved by the Invention]~~

As described above, when impurities in steel, such as S and Se, are insufficiently removed, the bend properties will deteriorate. In an inhibitor-free steel sheet, the contents of S and Se after purification annealing should be low enough so as not to affect the bend properties. Nevertheless, it became apparent that a final sheet product of inhibitor-free steel might have deteriorated bend properties. Thus, this indicates the presence of another cause of deterioration in the bend properties, other than the insufficient removal of S and Se.

Kindly replace the second paragraph on page 10 with the following:

Accordingly, it ~~is an object of the present invention~~ could be advantageous to improve the technique for manufacturing a grain-oriented electrical steel sheet without using inhibitors (inhibitor-free steel sheet) as disclosed in ~~Patent Document 6~~ Japanese Unexamined Patent Application Publication No. 2000-129356 and the like to prevent deterioration in the bend properties.

Kindly replace the paragraph bridging pages 10 and 11 with the following:

~~[Means for solving the Problems]~~ Summary

~~The present invention provides~~ We provide the following aspects:

(1) A method for manufacturing a grain-oriented electrical steel sheet with excellent bend properties, comprising the steps of:

rolling a steel slab containing 0.08 mass percent or less of carbon, 2.0-8.0 mass percent of Si, and 0.005-3.0 mass percent of Mn into a cold-rolled steel sheet;

subsequently performing decarburizing annealing of the cold-rolled steel sheet if desired;

subsequently applying an annealing separator to the cold-rolled steel sheet if desired;

performing secondary-recrystallization annealing of the cold-rolled steel sheet; and

subsequently performing purification annealing of the cold-rolled steel sheet,

wherein the steel slab contains less than 100 ppm of Al and not more than 50 ppm each of N, S, and Se, the purification annealing is performed at 1050°C or more, and the partial pressure of hydrogen in the atmosphere is adjusted to 0.4 atm or less in a temperature range above 1170°C for a purification annealing conducted at a temperature above 1170°C, or 0.8 atm or less in a temperature range of 1050°C or more for a purification annealing conducted at a temperature of 1170°C or less.

Kindly replace the last full paragraph on page 13 with the following:

~~Best Mode for Carrying Out the Invention~~ Detailed Description

~~The present invention will be described in detail below.~~

Kindly replace the paragraph bridging pages 13 and 14 with the following:

~~The present invention employs~~ We employ a method for promoting secondary-recrystallization without an inhibitor.

Kindly replace the first full paragraph on page 14 with the following:

As a result of diligent investigation on preferential secondary-recrystallization of Goss-oriented grain, ~~the present inventors have~~ we discovered that a grain boundary which has a

disorientation angle of 20-45° in a primary recrystallization structure plays an important role and reported this finding in Acta Material, 45, 1285 (1997).

Kindly replace the second paragraph on page 14 with the following:

Specifically, ~~the present inventors~~ we analyzed the primary recrystallized texture just before secondary-recrystallization of a grain-oriented electrical steel sheet, and studied the percentage (mass percent) of a grain boundary which has a disorientation angle of 20-45° for each grain boundary around crystal grains that have different crystal orientations. Fig. 1 shows the results. The Euler space is expressed by a cross-section at Φ_2=45° of Eulerian angles (Φ_1, Φ, Φ_2). Major orientations including Goss orientation are illustrated.

Kindly replace the first full paragraph on page 15 with the following:

Secondary-recrystallization in the conventional methods is known to occur with diffusion-controlled growth and coarsening of a precipitate known as an inhibitor. Considering these findings, ~~the present inventors~~ we believe that the precipitate on the high-energy grain boundary grows preferentially during the finishing-annealing, and thereby pinning of the grain boundary in the Goss orientation is preferentially removed to initiate grain boundary movement, and thus Goss-oriented grain grows.

Kindly replace the second paragraph on page 15 with the following:

~~The present inventors~~ We further developed this study and reached the following conclusion.

Kindly replace the paragraph bridging pages 17 and 18 with the following:

In other words, it might be possible to improve the bend properties by preventing silicon nitrides from precipitating at the grain boundary, even when nitrogen in the steel is insufficiently removed. As a result of diligent investigation, ~~the present inventors~~ we have discovered that by

controlling the hydrogen partial pressure depending on the annealing temperature during the purification annealing, precipitation of silicon nitrides at the grain boundary can be prevented while nitrogen remains in the steel~~, and came to perfect the invention~~.

Kindly replace the first full paragraph on page 18 with the following:

Although the reason the precipitation of silicon nitrides at the grain boundary is prevented is not clear, ~~the present inventors~~ we believe the reason as follows:

Annealing of a steel sheet at high temperature in a hydrogen atmosphere induces hydrogen attack, which embrittles a grain boundary of the secondary-recrystallization grain; that is, microvoids or fissures are formed at the grain boundary. Since these microvoids or fissures have exposed metal surfaces, silicon nitrides precipitate preferentially on the exposed metal surface, that is, in microvoids or fissures of the grain boundary when the temperature decreases during the purification annealing. The involvement of hydrogen attack is supported by the findings that a portion with deteriorated bend properties extends as a hydrogen attack promoter such as Sb increases in the steel.

Kindly replace the first paragraph on page 19 with the following:

Each constituent feature of the method for manufacturing the electrical steel sheet ~~according to the present invention~~ will be described below.

Kindly replace the paragraph bridging pages 27 and 28 with the following:

When these elements that accelerate hydrogen attack exceed about 0.5 mass percent in total, the bend properties will not be improved ~~even if the present invention is applied~~. Therefore, these elements should be 0.5 mass percent or less.

Kindly replace the paragraph bridging pages 28 and 29 with the following:

When finishing-annealing is performed on the coil in batch annealing, an electrical steel sheet ~~according to the present invention~~ exhibits excellent bend properties over the transverse direction of the coil. In other words, the bend properties after finishing-annealing are not deteriorated over the transverse ends. Thus, the bend properties of the ends are excellent after the finishing-annealing and the subsequent flattening step including flattening annealing. In addition, the stability of manufacturing line in the flattening step and the subsequent steps is also excellent.

Kindly replace the first full paragraph on page 29 with the following:

In the composition (excluding a film, such as a forsterite film) of the electrical steel sheet ~~according to the present invention~~, carbon is reduced to about 50 ppm or less, and S, Se, and Al are each reduced to about 15 ppm or less by purification treatment. Nitrogen is also reduced to about 35 ppm or less by the purification treatment (a typical analytical limit is about 5 ppm). Other components are similar to those of the slab.

Kindly replace the paragraph bridging pages 31 and 33 with the following:

Table 1 shows that the specimens that meet ~~the~~ our conditions ~~according to the present invention~~ exhibit excellent bend properties even at the transverse ends of the coils.

Kindly replace the first paragraph on page 36 with the following:

Tables 2-1 and 2-2 show that the specimens that meet ~~the~~ our conditions ~~according to the present invention~~ exhibit excellent bend properties even at the transverse ends of the coils. In particular, when 0.005 mass percent or more of Sb is contained, hydrogen in purification annealing is preferably limited to a lower level.

Kindly replace the first paragraph on page 39 with the following:

Table 3 shows that the specimens that meet ~~the~~ our conditions ~~according to the present invention~~ exhibit excellent bend properties.

Kindly replace the last paragraph on page 40 with the following:

~~According to the present invention, the bend~~ Bend properties of, in particular, a final sheet product of a grain-oriented electrical steel sheet manufactured without using an inhibitor are improved. Thus, a grain-oriented electrical steel sheet with excellent film properties can be consistently provided.